

AMENDMENTS TO THE CLAIMS

Please amend the claims as follows:

1 1. (Currently Amended) An optical chip, comprising:

2 at least one large mode field size dielectric waveguide to interface with an external  
3 optical device, said at least one large mode field size dielectric waveguide comprises a low index  
4 difference waveguide and said optical device comprises a low index difference waveguide;

5 at least one low minimum bending radius dielectric waveguide coupled to the large mode  
6 field size dielectric waveguide; and

7 at least one optical function connected to the low minimum bending radius dielectric  
8 waveguide;

9 wherein the large mode field size dielectric waveguide, the low minimum bending radius  
10 dielectric waveguide, and the optical function are fabricated monolithically on a single substrate.

1 2. (Original) The optical chip of claim 1, wherein the external optical device is a fiber optic  
2 waveguide.

1 3. (Original) The optical chip of claim 1, wherein the external optical device is selected from one  
2 or more of an edge emitting/receiving optical device and a vertically emitting/receiving optical  
3 device.

1 4. (Original) The optical chip of claim 1, wherein the external optical device is a large mode field  
2 size fiber optic waveguide on a separate chip.

1 5. (Original) The optical chip of claim 1, further comprising a coupler to couple the low  
2 minimum bending radius dielectric waveguide to the large mode field size dielectric waveguide,  
3 wherein the coupler includes:

4 a first dielectric channel waveguide including a first core material having a first

5 tapered region surrounded by a cladding material; and

6 a second dielectric channel waveguide including a second core material having a  
7 second tapered region surrounded by the cladding material, a portion of said second tapered  
8 region being embedded within said first tapered region, wherein a first mode for propagating  
9 lightwaves defined by the first dielectric channel waveguide gradually transforms into a second  
10 mode defined by the second dielectric channel waveguide.

1 6. (Original) The optical chip of claim 5, wherein the embedded portion of said second tapered  
2 region of the coupler is completely surrounded by said first tapered region in a cross-section  
3 transverse to a mode transformation direction.

1 7. (Original) The optical chip of claim 5, wherein the first tapered region of the coupler gets  
2 narrower in width in direction toward the second dielectric channel waveguide, and wherein the  
3 second tapered region gets narrower in width in direction toward the first dielectric channel  
4 waveguide.

1 8. (Original) The optical chip of claim 7, wherein the first tapered region and the second tapered  
2 region are graded in the horizontal direction.

1 9. (Original) The optical chip of claim 8, wherein the first tapered region and the second tapered  
2 region are graded in the vertical direction.

1 10. (Original) The optical chip of claim 5, wherein the large mode field size dielectric waveguide  
2 is optically coupled to the first dielectric channel waveguide of the coupler.

1 11. (Previously Presented) The optical chip of claim 10, wherein the first mode defined by the

2 first dielectric channel waveguide of the coupler is substantially the same as a mode defined by  
3 the large mode field size dielectric waveguide.

1 12. (Original) The optical chip of claim 10, wherein the low minimum bending radius dielectric  
2 waveguide is optically coupled to the second dielectric channel waveguide of the coupler.

1 13. (Previously Presented) The optical chip of claim 12, wherein the second mode defined by the  
2 second dielectric channel waveguide of the coupler is substantially the same as a mode defined  
3 by the low minimum bending radius dielectric waveguide.

1 14. (Original) The optical chip of claim 1, wherein the large mode field size dielectric waveguide  
2 is a low index difference dielectric waveguide, and wherein the low minimum bending radius  
3 dielectric waveguide is a high index difference dielectric waveguide

1 15. (Original) The optical chip of claim 14, wherein the low index difference dielectric  
2 waveguide includes a low index core and a cladding, wherein the index of refraction  $n_1$  of the  
3 low index core and the index of refraction  $n_3$  of the cladding are related as follows:

4 
$$0 < \frac{n_1 - n_2}{n_3} < 0.1.$$

1 16. (Original) The optical chip of claim 15, wherein the high index difference dielectric  
2 waveguide includes a high index core and the cladding, wherein the index of refraction  $n_2$  of the  
3 high index core and the index of refraction  $n_3$  of the cladding are related as follows:

4 
$$0.1 \leq \frac{n_2 - n_3}{n_3}.$$

1 17. (Original) The optical chip of claim 15, wherein:

2 
$$0 < \frac{n_1 - n_2}{n_3} < 0.04.$$

1 18. (Original) The optical chip of claim 16, wherein:

2 
$$0 < \frac{n_1 - n_2}{n_3} < 0.01.$$

1 19. (Original) The optical chip of claim 18, wherein:

2 
$$0.3 \leq \frac{n_2 - n_3}{n_3}.$$

1 20. (Original) The optical chip of claim 1, wherein the low minimum bending radius dielectric  
2 waveguide includes:

3 a high index core material defining a channel; a first cladding region generally  
4 surrounding the high index core material, wherein a refractive index  $n_2$  of the high index core  
5 material is greater than a refractive index  $n_3$  of the first cladding region; and  
6 a graded index region, wherein the graded index region is a separate region applied  
7 between at least one side of the high index core material and the first cladding region.

1 21. (Original) The optical chip of claim 20, wherein the graded index region has a refractive  
2 index that gradually changes from a refractive index of the high index core material to a  
3 refractive index of the first cladding region.

1 22. (Original) The optical chip of claim 20, wherein the at least one side having the graded index  
2 region is a rough edge of the high index core material.

1 23. (Original) The optical chip of claim 20, wherein the graded index region is applied between  
2 two rough sides of the high index core material and the first cladding region.

1 24. (Original) The optical chip of claim 20, wherein the graded index region is applied between  
2 each side of the high index core material and the first cladding region.

1 25. (Original) The optical chip of claim 20, wherein the first cladding region comprises two or  
2 more separate regions of cladding material.

1 26. (Original) The optical chip of claim 20, wherein the graded index region reduces scattering  
2 loss.

1 27. (Original) The optical chip of claim 1, wherein the optical function is any structure that  
2 performs at least one of generating, modifying, and measuring at least one of the amplitude,  
3 frequency, wavelength, dispersion, timing, propagation direction, and polarization properties of  
4 one or more light pulses.

1 28. (Withdrawn) An optical chip comprising a plurality of optical functions and at least one  
2 input/output port, wherein the optical functions and input/output port are fabricated on a  
3 substrate, the optical functions being optically connected with interconnection waveguides,  
4 wherein at least one of the interconnection waveguides between two or more of the optical  
5 functions is a low minimum bending radius waveguide, and wherein the optical chip includes at

6 least 5 optical functions per square centimeter.

1 29. (Withdrawn) The optical chip of claim 28, wherein the optical chip includes at least 10  
2 optical functions per square centimeter.

1 30. (Withdrawn) The optical chip of claim 28, wherein the low minimum bending radius  
2 waveguide includes a high index core material with an index of refraction  $n_2$  and a cladding  
3 material with an index of refraction  $n_3$ , wherein  $0.1 \leq \frac{n_2 - n_3}{n_3}$ .

1 31. (Withdrawn) The optical chip of claim 30, wherein  $0.3 \leq \frac{n_2 - n_3}{n_3}$ , and wherein the low  
2 minimum bending radius waveguide has a bending radius of no more than 50 microns.

1 32. (Withdrawn) The optical chip of claim 30, wherein the input/output port includes a low index  
2 difference waveguide, wherein the low index difference waveguide includes a low index core  
3 material having an index refraction  $n_1$  surrounded by the cladding material, wherein  
4  $0 < \frac{n_1 - n_2}{n_3} < 0.04$ .

1 33. (Withdrawn) A substrate comprising:

2 at least one optical function connected to at least one low minimum bending radius  
3 dielectric waveguide;

4 at least one large mode size dielectric waveguide to interface with an external optical  
5 device; and

6 a coupler to couple the low minimum bending radius dielectric waveguide with the large

7 mode size dielectric waveguide, wherein the coupler optically connects the low minimum  
8 bending radius dielectric waveguide with the large mode size dielectric waveguide with no more  
9 than 1 dB of loss.

1 34. (Withdrawn) The substrate of claim 33, wherein the high index difference dielectric  
2 waveguide includes a high index core material with an index of refraction  $n_2$  and a cladding  
3 material with an index of refraction  $n_3$ , wherein  $0.1 \leq \frac{n_2 - n_3}{n_3}$ .

1 35. (Withdrawn) The substrate of claim 34, wherein the low index difference dielectric  
2 waveguide includes a low index core material having an index of refraction  $n_3$  surrounded by the  
3 cladding material, wherein  $0 < \frac{n_1 - n_2}{n_3} < 0.04$ .

1 36. (Currently Amended) An apparatus, comprising:

2 a first optical chip including:

3 at least one large mode size dielectric waveguide, said at least one large mode field size  
4 dielectric waveguide comprises a low index difference waveguide and is coupled to an optical  
5 device that comprises a low index difference waveguide;

6 at least one low minimum bending radius dielectric waveguide coupled to the large mode  
7 size dielectric waveguide; and

8 at least one optical function connected to the low minimum bending radius dielectric  
9 waveguide, wherein the optical function, large mode size dielectric waveguide, and low  
10 minimum bending radius dielectric waveguide are monolithically fabricated on a single

11 substrate; and

12 a second optical chip including an emitting/receiving optical device to optically connect  
13 to the large mode size dielectric waveguide of the first optical chip.

1 37. (Original) The apparatus of claim 36, wherein a first end of the large mode size dielectric  
2 waveguide on the first optical chip includes an anti-reflection coating.

1 38. (Original) The apparatus of claim 36, wherein the emitting/receiving optical device on the  
2 second optical chip includes an anti-reflection coating.

1 39. (Withdrawn) A planar lightwave circuit substrate, comprising: at least one optical function  
2 connected to at least one low minimum bending radius dielectric waveguide, wherein the low  
3 minimum bending radius dielectric waveguide includes a high index core material, a first  
4 cladding region generally surrounding the high index core material, and a graded index region  
5 applied between at least one side of the high index core material and the first cladding region;  
6 at least one large mode size dielectric waveguide to interface with an external optical  
7 device; and

8 a coupler to couple the low minimum bending radius dielectric waveguide to the large  
9 mode size dielectric waveguide, wherein the coupler includes:

10 a first dielectric channel waveguide including a first core material having a first  
11 tapered region surrounded by a cladding material; and

12 a second dielectric channel waveguide including a second core material having a  
13 second tapered region surrounded by the cladding material, a portion of said second tapered  
14 region being embedded within said first tapered region, wherein a first mode defined by the first



15 dielectric channel waveguide gradually transforms into a second mode defined by the second  
16 dielectric channel waveguide, and wherein the first dielectric channel waveguide is optically  
17 connected to the large mode size dielectric waveguide and the second dielectric channel  
18 waveguide is optically connected to the low minimum bending radius dielectric waveguide.

1 40. (Currently Amended) An apparatus, comprising: an optical chip including  
2 at least one large mode field size dielectric waveguide to interface with an external  
3 optical device said at least one large mode field size dielectric waveguide comprises a low index  
4 difference waveguide and said external optical device comprises a low index difference  
5 waveguide;  
6 at least one low minimum bending radius dielectric waveguide coupled to the large  
7 mode field size dielectric waveguide; and  
8 at least one optical function connected to the low minimum bending radius dielectric  
9 waveguide, wherein the large mode field size dielectric waveguide, the low minimum bending  
10 radius dielectric waveguide, and the optical function are fabricated monolithically on a single  
11 substrate; and  
12 at least one external large mode field size dielectric ~~waveguide~~waveguide external to the  
13 optical chip and being optically connected to the optical chip.

1 41. (Original) The apparatus of claim 40, wherein a first end of the external large mode field size  
2 dielectric waveguide is optically connected to the large mode field size dielectric waveguide on  
3 the optical chip.

1 42. (Previously Presented) The apparatus of claim 41, wherein a second end of the external

- 2 large mode field size dielectric waveguide can interface with external optical devices.